processes

Supplementary Materials

Game Analysis of the Evolution of Energy Structure Transition Considering Low-Carbon Sentiment of the Decision-Makers in the Context of Carbon Neutrality

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The expected benefit of "green regulation" by government regulators is U_{1p}:

$$U_{1p}=[a(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)-c_1]e^{r2}+[h_1-d_1-R+l_1-c_1-\beta\eta Lq](1-e^{r2})$$
$$=[(a-1)(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)+\beta\eta Lq]e^{r2}+(h_1-d_1-R+l_1-c_1-\beta\eta Lq)$$

The expected benefit of "regular regulation" by government regulators is:

$$U_{2p}=[a(h_1-d_1)+b(h_2-d_2)-\theta Lq]e^{r2}+(h_1-d_1-Lq)(1-e^{r2})$$
$$=[(a-1)(h_1-d_1)+b(h_2-d_2)-(\theta-1)Lq]e^{r2}+(h_1-d_1-Lq) \tag{S4}$$

The average expected return for government regulators is $\overline{U_p}$:

$$\overline{U_p}=[a(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)-c_1]\omega_A(pe)+[h_1-d_1-R+l_1-c_1-\beta\eta Lq][\omega_A(p)-\omega_A(pe)]$$
$$+[a(h_1-d_1)+b(h_2-d_2)-\theta Lq][\omega_A(p+e-pe)-\omega_A(p)]+(h_1-d_1-Lq)[1-\omega_A(p+e-pe)]$$
$$=[(a-1)(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)+\beta\eta Lq](pe)^{r1}+[(1-a)(h_1-d_1)+a(-R+l_1)-c_1-b(h_2-d_2)-\beta\eta Lq+\theta Lq)]p^{r1}$$
$$+[(a-1)(h_1-d_1)+Lq+b(h_2-d_2)-\theta Lq](p+e-pe)^{r1}+(h_1-d_1-Lq) \tag{S5}$$

Government regulators replicated dynamic equation as $F(p)$:

$$F(p)=dp/dt=p^{r1}(U_{1p}-\overline{U_p})=p^{r1}$$
$$\left\{\begin{array}{l}[(a-1)(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)+\beta\eta Lq]e^{r2}+(h_1-d_1-R+l_1-c_1-\beta\eta Lq)\\-[(a-1)(h_1-d_1-R+l_1)+b(h_2-d_2-D+l_2)+\beta\eta Lq](pe)^{r1}\\-[(1-a)(h_1-d_1)+a(-R+l_1)-c_1-b(h_2-d_2)-\beta\eta Lq+\theta Lq)]p^{r1}\\-[(a-1)(h_1-d_1)+Lq+b(h_2-d_2)-\theta Lq](p+e-pe)^{r1}+(h_1-d_1-Lq)\end{array}\right\} \tag{S6}$$

The expected benefit of "integrated energy use" for energy consumers are U_{1n}:

$$U_{1n}=[a(-c_2+w_1+S)+b(-c_3+w_2+T)]m^{r1}+(-c_2+w_1+S-\eta Lq)(1-m^{r1})$$
$$=[(a-1)(-c_2+w_1+S)+b(-c_3+w_2+T)]m^{r1}+(-c_2+w_1+S-\eta Lq)+\eta Lqp^{r1} \tag{S7}$$

The expected benefit of "clean and efficient use of coal" for energy consumers is U_{2n}:

$$U_{2e}=[a(-c_2+w_1)+b(-c_3+w_2)-\beta\theta Lq]m^{r1}+(-c_2+w_1-Lq)(1-m^{r1})$$
$$=[(a-1)(-c_2+w_1)+b(-c_3+w_2)]m^{r1}+(-c_2+w_1-Lq)+(1+\beta\theta)Lqm^{r1} \tag{S8}$$

The average expected return for energy consumers is $\overline{U_n}$:

$$\overline{U_n}=[a(-c_2+w_1+S)+b(-c_3+w_2+T)]\omega_B(mn)+[-c_2+w_1+S-\eta Lq][\omega_B(m)-\omega_B(mn)]$$
$$+[a(-c_2+w_1)+b(-c_3+w_2)-\beta\theta Lq][\omega_B(m+n-mn)-\omega_B(m)]+(-c_2+w_1-Lq)[1-\omega_B(m+n-mn)]$$
$$=[(a-1)(-c_2+w_1+S)+b(-c_3+w_2+T)+\eta Lq](mn)^{r2}+[(1-a)(-c_2+w_1)+S-b(-c_3+w_2)+\beta\theta Lq-\eta Lq]m^{r2}$$
$$+[(a-1)(-c_2+w_1)+Lq+b(-c_3+w_2)-\beta\theta Lq](m+n-mn)^{r2}+(-c_2+w_1-Lq) \tag{S9}$$

The energy consumers replicated dynamic equation for $F(n)$:

$$F(n) = dn/dt = n^{r2}(U_{1n} - \overline{U_n}) = n^{r2}$$

$$\left\{\begin{array}{l}[(a-1)(-c_2+w_1+S)+b(-c_3+w_2+T)]p^{r1}+(-c_2+w_1+S-\eta Lq)+\eta Lqm^{r1} \\ -[(a-1)(-c_2+w_1+S)+b(-c_3+w_2+T)+\eta Lq](mn)^{r2}-[(1-a)(-c_2+w_1)+S-b(-c_3+w_2)+\beta\theta Lq-\eta Lq]m^{r2} \\ -[(a-1)(-c_2+w_1)+Lq+b(-c_3+w_2)-\beta\theta Lq](m+n-mn)^{r2}-(-c_2+w_1-Lq)\end{array}\right\} \quad (S10)$$

Let $A_1 = (a-1)(y_1 - x_1 - S + l_1) + b(y_2 - x_2 - T + l_2) + \beta\eta Lq$

Let $A_2 = (1-a)(-y_1 + x_1 + S - l_1) + b(y_2 - x_2 - T + l_2) + \beta\eta Lq$

Let $A_3 = (1-a)(y_1 - x_1) + a(-S + l_1) - c_1 - b(y_2 - x_2) - \beta\eta Lq + \theta Lq$

Let $A_4 = (a-1)(y_1 - x_1) + Lq + b(y_2 - x_2) - \theta Lq$

Let

$$A_5 = (y_1 - x_1 - S + l_1 - c_1 - \beta\eta Lq) + (y_1 - x_1 - Lq) = 2(y_1 - x_1) - S + l_1 - c_1 - \beta\eta Lq - Lq$$

Let $B_1 = 2(a-1)(-c_2 + w_1) + (a-2)S + 2b(-c_3 + w_2) + bT + 2\eta Lq - \beta\theta Lq$

Let $B_2 = (a-1)(-c_2 + w_1 + S) + b(-c_3 + w_2 + T) + \eta Lq$

Let $B_3 = (a-1)(-c_2 + w_1) + Lq + b(-c_3 + w_2) - \beta\theta Lq$

Let $B_4 = S - \eta Lq + Lq$